

CLAIMS

1. A method for producing a freestanding group-III-nitride substrate from a starting substrate, by the deposition  
5 of a group-III nitride by epitaxy, wherein it includes the use, on the aforementioned starting substrate, of a silicon-based intermediate layer as a sacrificial layer intended to be vaporized spontaneously during the later step of the epitaxy of the group-III nitride.

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2. A method according to claim 1, wherein the group-III nitride is selected among  $\text{AlN}$ ,  $\text{Al}_x\text{Ga}_{1-x}\text{N}$ ,  $\text{In}_x\text{Ga}_{1-x}\text{N}$  and  $\text{Al}_x\text{Ga}_y\text{In}_{1-x-y}\text{N}$  (where  $0 \leq x+y \leq 1$ ).

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3. A method according to claim 2, wherein the group-III nitride is gallium nitride.

4. A method according to any one of the claims 1 to 3, wherein the silicon-based intermediate layer is of silicon, of  
20 silicon that includes impurities chosen among aluminum, indium, gallium, phosphorus and boron, or of SiGe.

5. A method according to any one of the claims 1 to 4, wherein the silicon-based intermediate layer is obtained by  
25 deposition or by bonding on the substrate.

6. A method according to any one of the claims 1 to 5, wherein the silicon-based intermediate layer is a single-crystal silicon layer oriented according to the direction  
30  $\langle 111 \rangle$ ,  $\langle 110 \rangle$  or  $\langle 100 \rangle$ .

7. A method according to claim 6, wherein the single-crystal silicon layer is grown epitaxially according to the direction  $\langle 111 \rangle$ .

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8. A method according to any one of the claims 1 to 7, wherein the silicon-based intermediate layer is in continuous, discontinuous ordered or discontinuous disordered form.

5 9. A method according to any one of the claims 1 to 8, wherein the silicon-based intermediate layer has a thickness that lies in the range between 100 nm and 10  $\mu\text{m}$ .

10 10. A method according to any one of the claims 1 to 9, wherein a group-III-nitride layer of a thickness greater than 50  $\mu\text{m}$  is deposited.

11. A method according to any one of the claims 1 to 10, wherein the substrate is selected among sapphire, SiC, quartz,  
15  $\text{MgAl}_2\text{O}_4$ , AlN and GaN or a combination thereof.

12. A method according to any one of the claims 1 to 11, wherein the substrate is sapphire.

20 13. A method according to any one of the claims 1 to 12, wherein the substrate is sapphire according to the C-plane (0001) or the R-plane (10-12) or the M-plane (1-100).

25 14. A method according to any one of the claims 1 to 13, wherein a nucleation layer chosen among AlN, SiC, low-temperature GaN, AlGa<sub>x</sub>In<sub>1-x-y</sub>N (where  $0 \leq x+y \leq 1$ ),  $\text{Al}_2\text{O}_3$ , AlAs, GaAs or a combination of these various layers is deposited on the silicon-based sacrificial layer before the epitaxial growth of the group-III nitride.

30 15. A method according to claim 14, wherein an initial group-III-nitride layer is deposited on the nucleation layer before the growth of the bulk group-III nitride.

35 16. A method according to claim 15, wherein the thicknesses of the nucleation layer defined in claim 14 and that of the initial group-III-nitride layer defined in claim

15 lie between 0.01 and 0.5  $\mu\text{m}$ , and 0.1 and 10  $\mu\text{m}$ , respectively.

17. A method according to claim 16, wherein the growth  
5 rate of the nucleation layer defined in claim 14 and the initial group-III-nitride layer defined in claim 15 lie between 0.01 and 3  $\mu\text{m}/\text{h}$ .

18. A method according to any one of the claims 1 to 17,  
10 wherein it comprises the following successive steps:

- (i) the deposition or the bonding on a substrate of a silicon-based sacrificial layer,
- (ii) the deposition of a nucleation layer,
- (iii) the deposition by epitaxy of a thick layer of the  
15 group-III-nitride on the bilayer (silicon-based intermediate layer/nucleation layer), under operating conditions compatible with a spontaneous vaporization of the silicon-based sacrificial layer.

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19. A method according to any one of the claims 1 to 18, wherein the growth conditions of the thick layer of the group-III nitride are defined by the following parameters, taken separately or preferentially in combination:

- 25 - the pressure lies in the range between  $10^2$  and  $10^5$  Pa,
- the temperature lies in the range between 800  $^{\circ}\text{C}$  and 1200  $^{\circ}\text{C}$ ,
- the growth rate lies in the range between 10 and 200  $\mu\text{m}/\text{h}$ .

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20. A method according to any one of the claims 1 to 19, wherein the nucleation layer can be deposited, in the case when the sacrificial layer is not continuous, either exclusively on the sacrificial layer, or exclusively on the  
35 areas of the substrate not covered by the sacrificial layer, or over the entire surface of the sacrificial layer and the bare areas of the substrate.

21. A method according to any one of the claims 1 to 20, wherein the method includes an additional step of the elimination of the residues of the silicon-based intermediate layer that remain after the group-III-nitride layer growth step by chemical etching of this silicon-based intermediate layer.

22. A method according to any one of the claims 1 to 21, wherein part or all of the growth of the group-III-nitride layer is carried out by vapor phase epitaxy, HVPE or MOVPE, with MOVPE able to be substituted by MBE.

23. A method according to any one of the claims 1 to 22, wherein the group-III-nitride layer is deposited in two steps, a first step at a low growth rate according to a MOVPE or MBE technique, and a second step of the thickening of the layer by a HVPE technique.

24. A method according to the claim 23, wherein the group-III-nitride layer deposited in the first step defined in claim 23 is deposited at a speed that lies in the range between 0.1 and 5  $\mu\text{m/h}$ .

25. A method according to any one of the claims 1 to 24, wherein the group-III nitride can be doped by a doping material able to be selected from the group comprising magnesium, zinc, beryllium, calcium, carbon, boron, chromium, silicon and iron.

26. A freestanding substrate of group-III nitride likely to be obtained according to any one of the claims 1 to 25, wherein its diameter is equal to or greater than 2" and wherein it possesses a radius of curvature greater than 5 m.

27. A freestanding substrate of group-III nitride according to claim 26, wherein its diameter is equal to or

greater than 2" and wherein it possesses a radius of curvature greater than or equal to 10 m.